Experiments In the Control Of Schistosomiasis In Brazil

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Australorbis glabratus

SCHISTOSOMIASIS, a disease caused by three species of human blood flukes, *Schistosoma haematobium*, *S. mansoni*, and *S. japonicum*, is widely distributed in Africa, the Near East, the Orient, the Caribbean area, and parts of South America. It has been estimated (*1*) that there are 114,400,000 individuals in the world who are infected with the disease. It usually runs a chronic course, and the patient may suffer for years before finally succumbing to the cumulative damage or intercurrent infection. In most endemic areas, natives are continually exposed to the disease, and repeated infections are the rule.

Schistosomiasis is not an acute fulminating disease with the spectacular manifestations of cholera, yellow fever, or some other bacterial or viral infections. Because of this, the public health importance of schistosomiasis has received little attention until recently. However, now that the success of residual insecticides in malaria control has been demonstrated, health agencies in some countries are encouraged to devote more attention to the possibilities of

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Dr. Dobrovolny, a parasitologist on the staff of the laboratory of tropical diseases, National Microbiological Institute, National Institutes of Health, came to the Public Health Service in 1948 from the University of New Hampshire, where he was chairman of the division of biological sciences. He participated in the laboratory's malaria study in Guatemala in 1948–50 and since 1951 has been at Recife, Brazil, working on the field experiments with molluscacides.

On the frontispiece of this issue of Public Health Reports are shown all stages in the life cycle of the human blood fluke, Schistosoma mansoni.

controlling schistosomiasis by means of vector elimination.

An Economic Burden

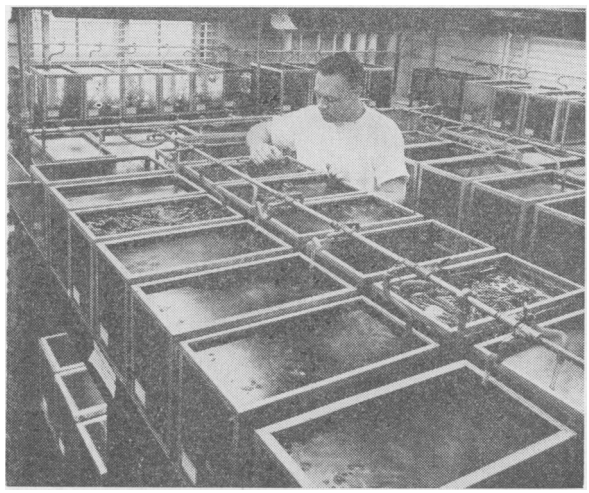
Because of its debilitating nature, schistosomiasis exacts a considerable economic toll in many areas in which it is endemic. In Egypt, it is estimated that the disease costs the country approximately $57 million a year and lowers the productivity of the population by 33 percent. In Japan, health officials of Fukuoka and Saga prefectures have estimated that the cost of the disease in the endemic area on the island of Kyushu runs to $2,522,200 a year in wages alone, not counting costs of medical care. Since schistosomiasis is highly endemic in many of the world areas from which the United States draws strategic materials, the disease, along with other tropical infections, represents a substantial tax on imports which this country buys from such areas.

In 1943, the laboratory of tropical diseases of the Public Health Service undertook, at the request of the Surgeon General of the Army, certain studies on schistosomiasis of importance from the standpoint of military preventive medicine. Somewhat later, when it appeared that military personnel might become infected with the disease and serve as focuses for possible establishment of the disease in the continental United States, experiments were undertaken to determine whether any domestic species of snails could serve as intermediate hosts. The effect of water and sewage treatment processes on infectious material was also studied.

Studies on Snail Destruction

The availability of suitable snail hosts in laboratory colonies provided the opportunity for studies on snail destruction as a method of control for the disease. These studies were inaugurated after World War II, and many hundreds of chemical compounds were screened for their effectiveness against *Australorbis glabratus*, the snail which serves as intermediate host of *S. mansoni* in the Caribbean area and certain parts of South America (*2*). The results of the laboratory tests provided data for a correlation between chemical structure and molluscacidal activity and indicated a number of compounds with sufficient promise for field testing. Initial tests were carried out in Texas (*3*) against snails closely related to vectors in South America and later against *A. glabratus* in endemic areas of the disease in Puerto Rico (*4*). Subsequently, in cooperation with the Mutual Security Agency and the British Colonial Office, tests were extended to Nigeria and Sierra Leone by personnel of the laboratory of tropical diseases.

Among the chemicals tested in the field, sodium pentachlorophenate has proved one of the most effective. This chemical is in ready supply commercially and is reasonable in cost. In one test in Puerto Rico, a single application costing $7 destroyed all *A. glabratus* present in a stream 3⅓ kilometers long, and the area remained free of infestation for several months. At Tudun Wada, Nigeria, $3 worth of the chemical eradicated all of the schistosome vectors (*Biomphalaria pfeifferi* and *Physopsis africana*) from a stream 2.2 km. in length, and the stream remained free of these snails for nearly 11 months. At Rigachikun in northern Nigeria, these same species were eradicated and remained absent for 16 months from a stream 4.4 km. in length at a cost of less than a half penny per person of the population in the area.



Technician removes snails from tanks in preparation to test snail-killing efficacy of chemicals. Experiments conducted at the laboratory of tropical diseases, National Institutes of Health, Public Health Service, Bethesda, Md.

No Specific Treatment

The attack on the molluscan intermediate host offers one of the most promising approaches to the control of schistosomiasis. At the present time, there is no specific treatment for the disease, and efforts to effect control through chemotherapy have generally resulted in failure. Sanitary control through the proper disposal of excreta containing the ova of the parasite is complicated in many parts of the world because of religious or agricultural practices. Furthermore, many workers in certain types of agriculture are constantly exposed to infection, thus creating an occupational hazard. For these reasons, it would be difficult to change present practices for the purpose of avoiding infection.

Cooperative Project in Brazil

The preliminary field trials on snail destruction led to an extended study of certain molluscacides under field conditions in Brazil. This cooperative project was begun in February 1951 under the auspices of the Pan American Sanitary Bureau and at the invitation of the Ministry of Education and Health of Brazil. Two scientists from the laboratory of tropical diseases, National Institutes of Health, were detailed to the project, and transportation in the country, technical assistance and equipment, and laboratory space were provided by the Brazilian Ministry of Education and Health.

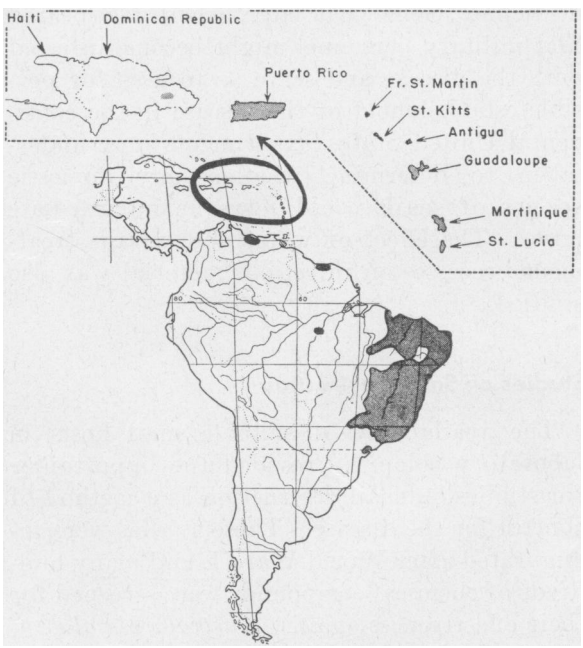
Headquarters for the project were established at the Instituto Aggeu Magalhães in the seaport city of Recife in the state of Pernambuco, which is in the heart of a highly endemic schistosomiasis region. This region, 7° to 15° south of the equator, extends from a narrow littoral along the Atlantic Coast to a low plateau several hundred miles inland. The plateau is intersected by numerous small rivers along which most of the villages and towns are located. The climate is tropical, humid along the coast, and dry in the semidesert area in the interior. The annual rainfall ranges from about 80 inches along the coast to a few inches on the inland plateau, almost all of it falling in the months from March to September.

The snail intermediate hosts, *A. glabratus* and species of *Tropicorbis*, inhabit many of the fresh water streams, lakes, and drainage and irrigation ditches in this region. Because sanitary facilities, except in the largest cities, are completely lacking, these waters are used for all washing, bathing, and laundering. Water for cooking and drinking is frequently procured from the same sources.

Field Trials With 33 Chemicals

Thirty-three chemicals which had proved to be 100 percent effective against *A. glabratus* in concentrations of 10 ppm or less in tests conducted in the laboratory of tropical diseases were sent to Brazil for field trials.

Initial field trials with each compound were made in isolated test plots in still water pools or ditches. In some instances, dams were constructed in ditches to isolate control areas from treatment areas. Just before application of the chemical, the volume of water in liters of each test plot was computed from measurements of the length and the mean width and depth.



The highly endemic schistosomiasis regions in the Caribbean area and in South America are shown above in the shaded areas. Note particularly the coastal area of Brazil.

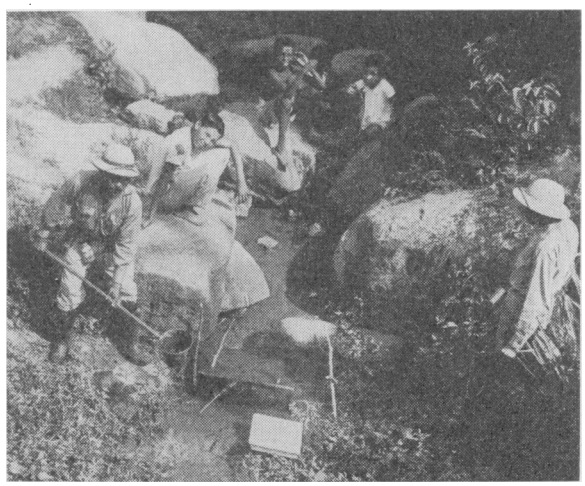
In the first experiments with each compound, the same method of application was employed—a solution or suspension of the chemical dispensed with a compressed air sprayer at a calculated rate of 10 ppm. Later, other methods of application, depending on the composition of the compound, were often employed. Some compounds were mixed with inert materials like talcum and applied with rotary dusters. Compounds in solution were soaked in dry sawdust, which was then dispersed by hand (*5*). The different methods employed with a given compound were usually about equally effective. Compounds found to be effective applied at 10 ppm were then tried in lower concentrations.

The pretreatment snail survey of each test plot was made shortly before the chemical was applied. Posttreatment surveys to determine the effects of the compounds on snails were made weekly or more frequently. The effectiveness of the chemical in each survey of each experiment was expressed in the percentage reduction in the snail population. The effectiveness at 10 ppm of 33 compounds in preliminary field trials in static waters was determined over a 6-week period following application. The results beyond 6 weeks of observation are not directly comparable because some test plots dried up.

The effectiveness of 8 of the 33 compounds tested was 90 percent or less. With 18 compounds, results of various trials showed complete kill of snails in some instances but only 90 percent reduction in snail population in others. The remaining 7 compounds found to be 99 to 100 percent effective against the snails in all tests were: pentabromophenol; pentachlorophenol (Hercules special emulsion); copper pentachlorophenate; sodium pentachlorophenate; bis(3,5,6-trichloro-2-hydroxyphenyl) methane; sodium salt of bis(3,5,6-trichloro-2-hydroxyphenyl) methane; and phenyl mercuric acetate. Most of the above compounds were also 95 to 100 percent effective when applied at a concentration of 2 ppm.

Value of Sodium Pentachlorophenate

Since many of the flowing streams in the highly endemic schistosomiasis region of Brazil are infested with snails, it is essential that molluscacides be effective in flowing water. Of the chemicals tested in streams, sodium pentachlorophenate proved to be the most effective. Because this chemical is not very toxic to mammals in the concentrations employed, it was used in extensive field trials in flowing waters.



Workers collect snails from one of the snail-infested streams in the state of Pernambuco, Brazil.

In these experiments, the compound was usually applied at the head of the stream and in some instances at selected intervals along the stream. The amount of chemical to be applied was calculated from the rate of flow for a given number of hours at selected levels downstream. In most streams, the rate of flow was determined with the aid of a pigmy current meter or by construction of a weir. Different methods of application employed gave satisfactory results. Observations were also made on the rate and extent of dispersion of the compound in streams from samples of water (*6*) taken at various points below the sites of application. It was found that the disappearance of chemical from the water below the site of application in the stream was usually greater than expected on the basis of calculation. In most of the streams, the rate of disappearance was so rapid that little chemical was carried downstream more than 4,000 feet.

As might be expected from the above observations, the kill of snails was least successful in the lower parts of the stream. In most of the streams, the chemical was most effective in the area down to 1,000 feet below the site

of application, indicating the intervals at which application should be made. It was also found that sodium pentachlorophenate is usually most effective when applied at concentrations of at least 10 ppm. On the other hand, concentrations exceeding 20 ppm applied for 8 hours or more did not enhance the molluscacidal effects of the compound. The effectiveness is a function of time of application as well as of concentration. Thus concentrations as low as 2 ppm maintained for 40 hours were about as effective as high concentrations for 8 hours.

Effective Snail Abatement

A marked reduction—frequently 100 percent—of snail populations in streams was observed following a single application of sodium pentachlorophenate. No living snails were found in 11 of 28 streams during the first month after treatment, and in parts of some streams no living snails were discovered over a 12-month period. However, most of the waters from which the snails appeared to have been eradicated were repopulated by the fourth month after treatment. The sudden appearance of mature and large specimens in snail-free waters indicated that reinfestation was accomplished by snails which were not in the water at the time the chemical was applied. These streams appeared to have become reinfested in a number of ways. In moist, shady habitats, snails often migrate to the wet banks, and following treatment may return to the streams. Snails left stranded on the banks of streams following high waters and snails raked on the banks with vegetation when streams are cleaned go into estivation. During rains they may migrate or be washed back into the snail-free waters.

Since a single application usually produced effective control for about 3 months, various field trials were made to determine the effects of repeated applications of sodium pentachlorophenate at different levels of the stream and at selected intervals of time. In most of the surveys made in these streams for periods up to 12 months, the reduction in the snail population was 95 to 100 percent, based on the first pretreatment snail counts. Results with the experiments conducted to date illustrate that effective snail abatement can be attained by treatments at intervals of 3 or 4 months. However, because of the ability of snails to survive in some of the ways mentioned, eradication of snails cannot be accomplished in 1 year.

In view of the different conditions under which sodium pentachlorophenate was applied, variable results were to be expected. Compared with the results reported elsewhere, there are indications that the technique of application of molluscacides may require considerable variation from one geographic area to another, depending on the ecologic conditions of the snails. In the main, the results obtained in Brazil have served to clarify some of the problems encountered in snail control and to suggest the need and direction for further experiments in the solution of these problems.

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